REPORT DOCUMENTATION PAGE

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14. ABSTRACT
The goal of this project is the establishment of a new laser facility at Norfolk State University for conducting research and education in high intensity, ultrashort pulse (USP) laser-matter interactions. The new research capabilities are based upon three state-of-the-art laser systems, a Spectra Physics Topas OPA operating at < 100 fs, 50-150 microjoules , 1 kHz, and 1100 -2900 nm, a Spectra Physics TOPAS Prime OPA operating at < 100 fs, 50-150 microjoules, 1 kHz, and 290 -2900 nm, and a Spectra Physics Solstice ACE regenerative amplifier operating at

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Report Title

Final Report: Acquisition of Instrumentation for Research and Education in Ultrashort Pulse Laser Spectroscopy and Nanomachining

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Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received	Book

TOTAL:

Received	Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 2.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:...... 2.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:...... 2.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):...... 2.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:...... 2.00

Names of Personnel receiving masters degrees

NAME
Total Number:

Names of personnel receiving PHDs

NAME
Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Technology Transfer

Abstract

The goal of this project is the establishment of a new laser facility at Norfolk State University for conducting research and education in high intensity, ultrashort pulse (USP) laser-matter interactions. The new research capabilities are based upon three state-of-the-art laser systems, a Spectra Physics Topas OPA operating at < 100 fs, 50-150 μJ, 1 kHz, and 1100 -2900 nm, a Spectra Physics TOPAS Prime OPA operating at < 100 fs, 50-150 μJ, 1 kHz, and 290 -2900 nm, and a Spectra Physics Solstice ACE regenerative amplifier operating at 100 fs, 1kHz, 0.80 mJ, and 800 nm. These systems are currently being used for z-scan spectroscopy of nonlinear optical materials, fabrication of nanostructures through two-photon polymerization, and two-dimensional infrared spectroscopy of biological systems.

Results Summary

Research Capabilities

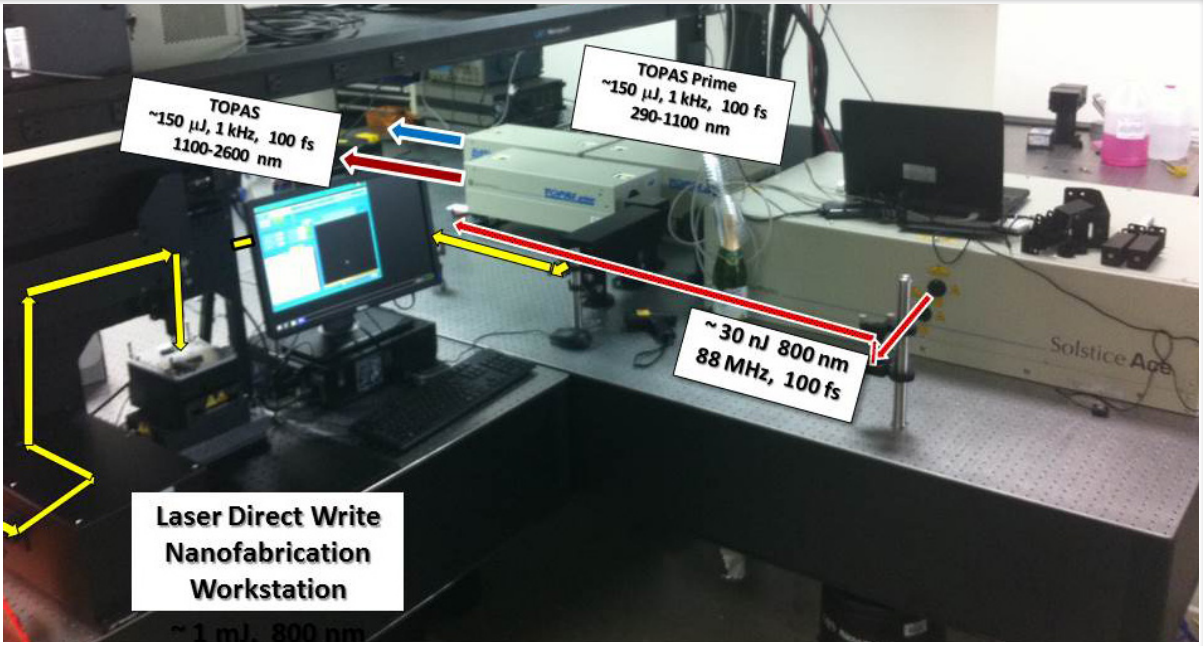


Figure 1. Photograph of the laser systems and laser direct write fabrication workstation.

The laser systems and laser direct write (LDW) microfabrication workstation, shown in figure 1, were installed during the fall 2015 semester. One of the outputs from the Solstice Ace amplifier is shown exiting the side of the system (indicated by a red arrow) which is unused laser power from the internal fs Mai Tai laser. This beam is about 2.5 W at 800 nm. The amplified beam is about 5 W at 800 nm and 1 kHz is split into three components which are used as the pump the TOPAS Prime system, the pump for the TOPAS system (1100-2900 nm), and the source for the LDW workstation.

The LDW workstation is shown in figure 2. The inset photo shows an air plasma voxel generated by 10 nJ pulses at 1 kHz. The computer shown at right, controls the 3D scanning system which can be configured to produce 3D nanostructures using TPP.

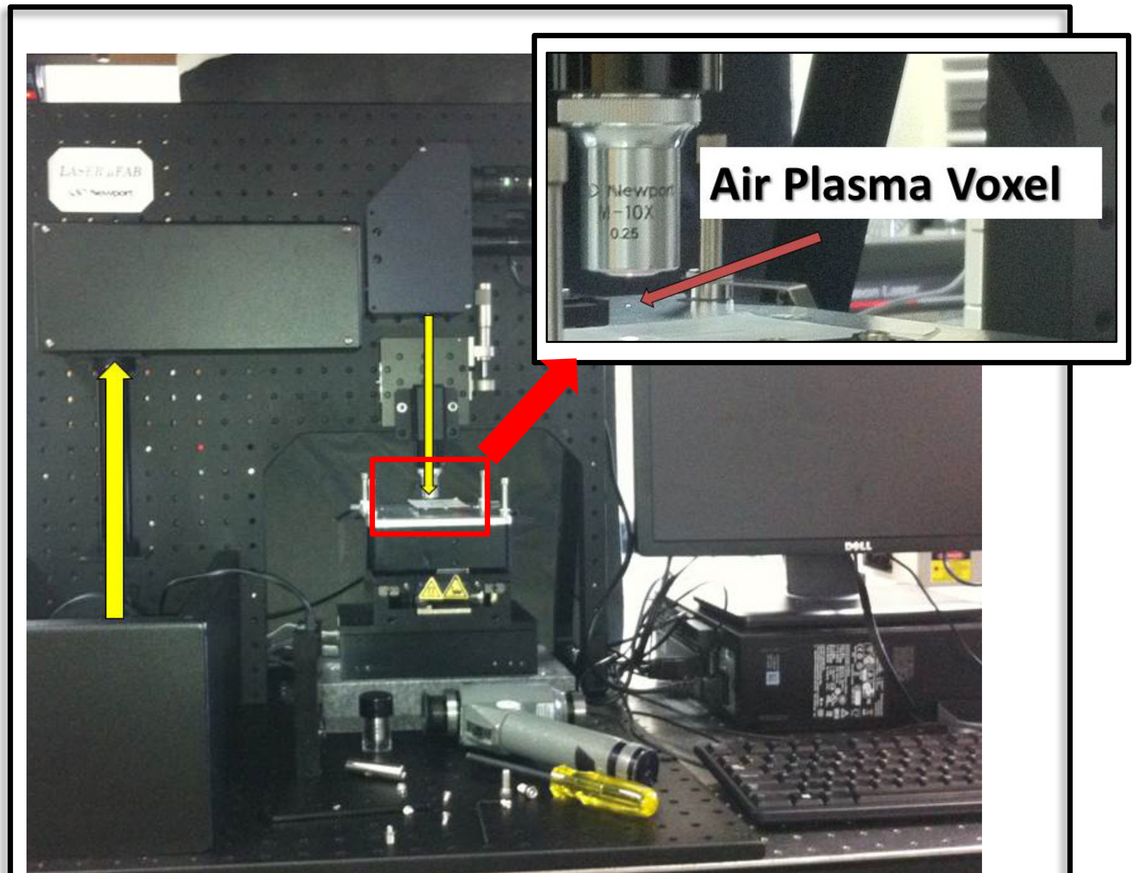


Figure 2. Photograph of the LDW workstation. An air plasma voxel can be seen in the insert.

In the coming year these systems will be used for experiments involving:

1. Z-scan spectroscopy of multi-photon processes in nonlinear materials,
2. Investigation of Laser Induced Breakdown Spectroscopy (LIBS) mechanisms in the fs time scale,
3. Two-dimensional infrared spectroscopy studies of quantum decoherence mechanisms in biological systems,
4. Fabrication of 3D metamaterials

EDUCATION AND OUTREACH

<u>High School Students</u>

Three high school rising sophomores, Mr. Craig Edwards, Mr. Kavon Barrett, and Ms. Tenderly Diaz have been working in the lab since July 2015. They are currently working on research part time during the academic year and will continue their research for the remaining three years of high school. Their projects were:

<u>Mr. Kavon Barrett</u>

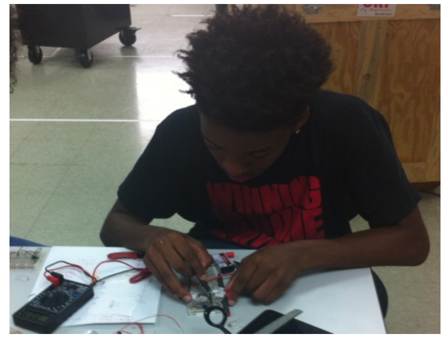
Design and Construction of Laser Power Meters Using Op-Amps and Silicon Photodetectors.

<u>Mr. Craig Edwards</u>

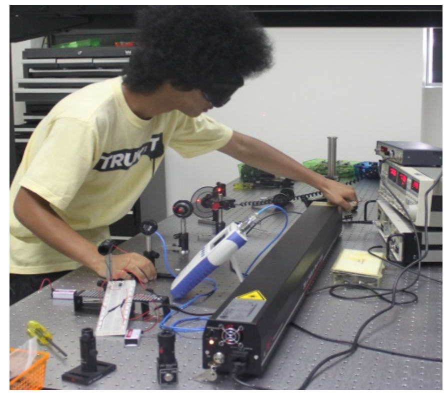
Optical System for Measurement and Calibration of Laser Power Photodetectors

<u>Ms. Tenderly Diaz</u>

Photodetector Response Calibration Using Statistical Analysis with MathCAD



(a)



(b)

(c)

Figure 3. Photographs of the high school students that worked on the project. (a) Mr. Kavon Barrett, (b) Mr. Craig Edwards, (c) Ms. Tenderly Diaz were 9th grade students.

Undergraduate Student

Mr. Christopher Atkinson is a scholar in the Dozoretz National Institute for Mathematics and Applied Sciences (DNIMAS) program, which is an on-campus program that provides STEM honors students with research and academic training to enhance their matriculation to graduate school.

Figure 4. Photograph of Mr. Christopher Atkinson working on a Labview data acquisition system.

Mr. Christopher Atkinson

Design and Construction of a z-Scan Materials Diagnostics System Using Labview

Mr. Devon Courtwright

Ultrashort Pulse Laguerre-Gaussian Beam Shaping for 3D Laser Nanofabrication

Mr. Javon Knox

Ultrashort Pulse Spectroscopy of Surface Plasmon Polaritons in Nanostructures

Graduate Student

Mr. Quincy Williams is a graduate student working on the project. He has passed all of the required graduate courses and qualifying examinations and his project is fabrication of 3D metamaterial structures for applications in nano-optics. He is shown at right giving a presentation on his work in France as part of an NSF IGERT student professional development grant.

Figure 5. Photograph of Mr. Quincy Williams presenting a seminar on his work at the the Charpak Center of Microelectronics and Biotechnology in in Provence France on July 7, 2014.